

A 0.05 degree global climate/interdisciplinary long term data set from AVHRR, MODIS and VIIRS

*PI & Co-I's:*

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- *UMD:* Eric Vermote & Steve Prince.
- *South Dakota State University:* David Roy

*Collaborator:* Chris Justice (UMD).

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# Land Long Term Data Record

- Develop and produce a global long term coarse spatial resolution (0.05deg) data record from AVHRR, MODIS and VIIRS for use in global change and climate studies.
- Use a MODIS-like operational production approach including an operational QA team.
- Set up an advisory process.
- Make intermediate versions of the data sets available to the community through a web interface and solicit input from users.
- Hold community workshops for outreach and feedback.
- Prototype the development and production of a climate quality data record.

# Proposed LTDR Products

AVHRR, MODIS, [VIIRS]:

- VIS/NIR surface reflectance

- MIR surface reflectance

- Vegetation Indices

- Surface temperature and emissivity

- Snow

- LAI/FPAR

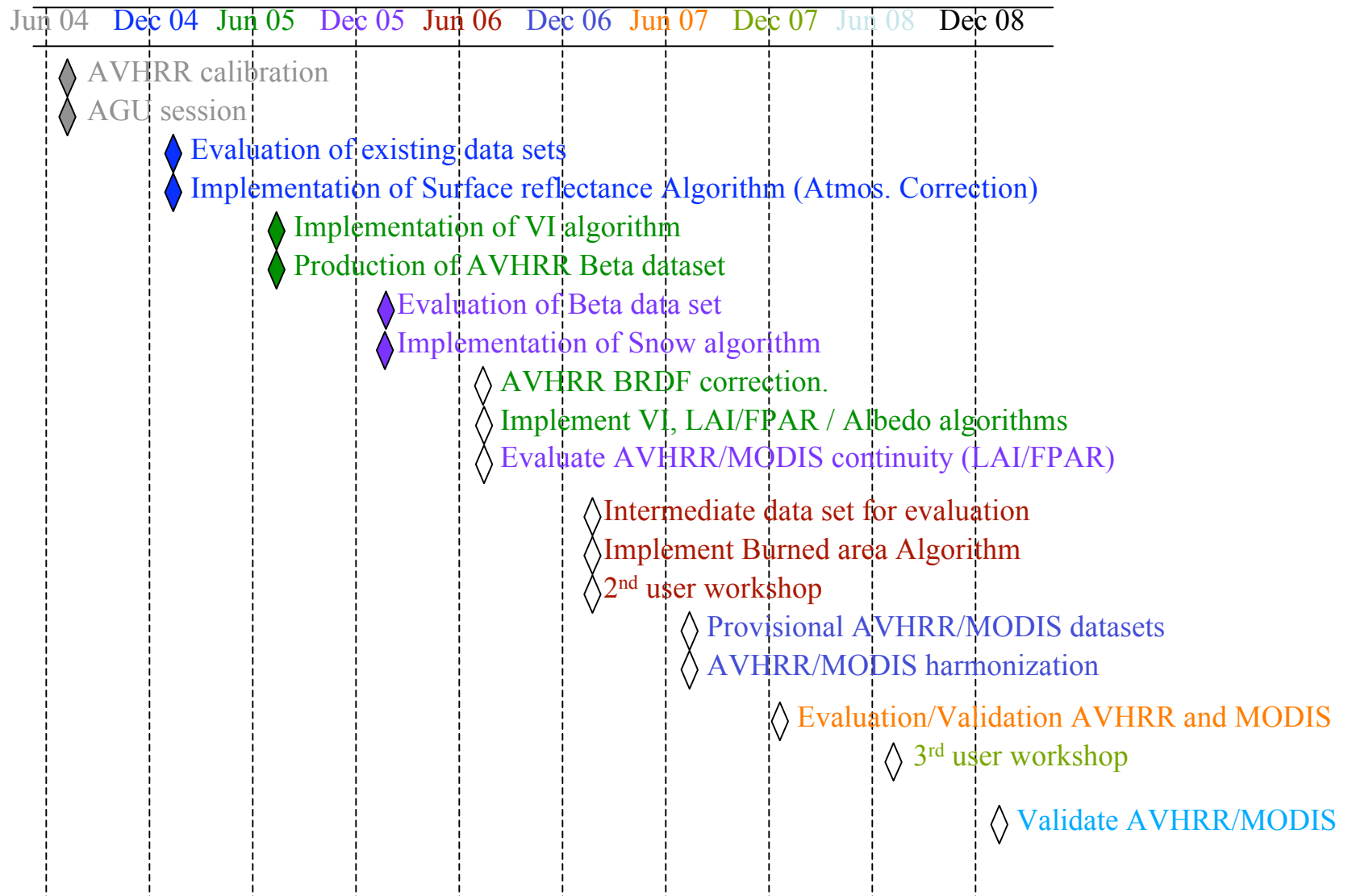
- BRDF/Albedo

- Aerosols

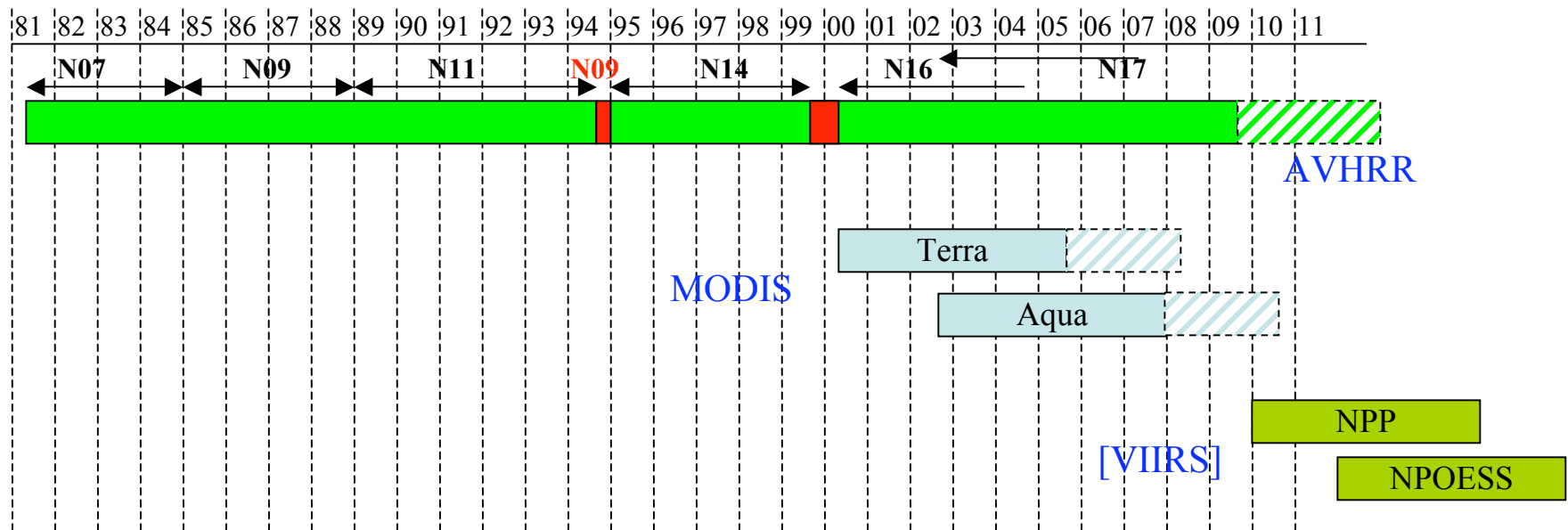
- Burned area

Products and formats will be modified based on feedback from the User Community Workshops.

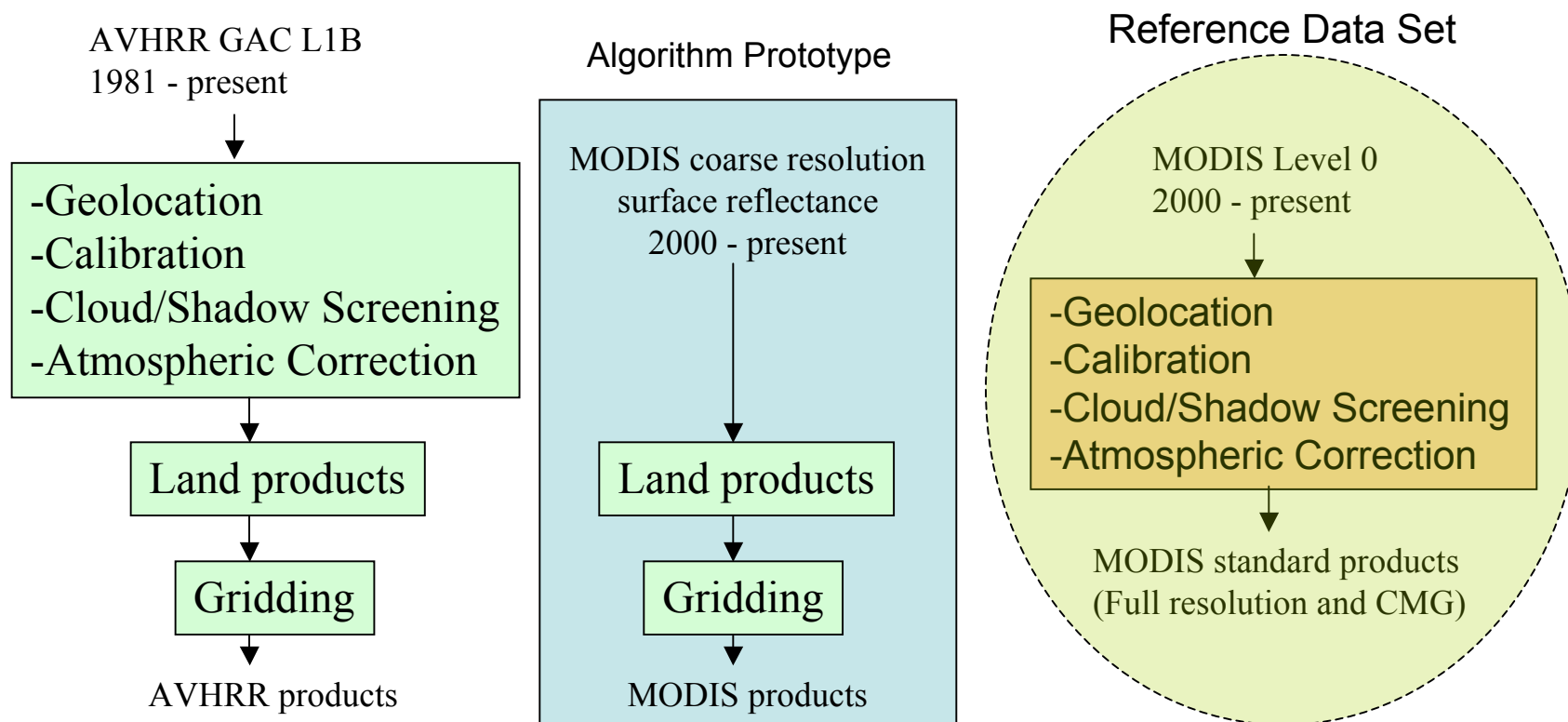
# Project milestones



# Data Sources



# AVHRR and MODIS Production Systems



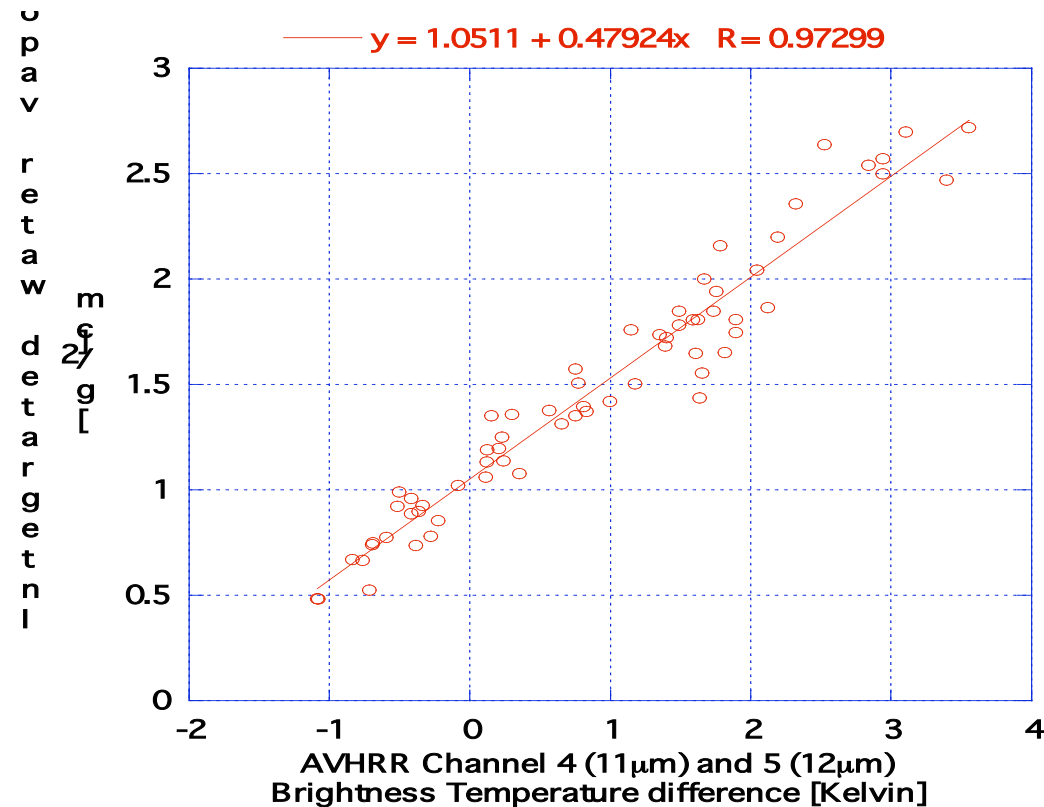
## List of potential products:

Surface Reflectance, VI,  
Surface Temperature and emissivity,  
Snow, LAI/FPAR, BRDF/Albedo,  
Aerosols, burned area

## Format:

HDF  
Geographic projection 1/20 deg resolution  
Daily, multi-day, monthly

# Use of MODIS to improve AVHRR atmospheric corrections



Use coincident MODIS/AVHRR data to develop an approach for water vapor retrieval from AVHRR.

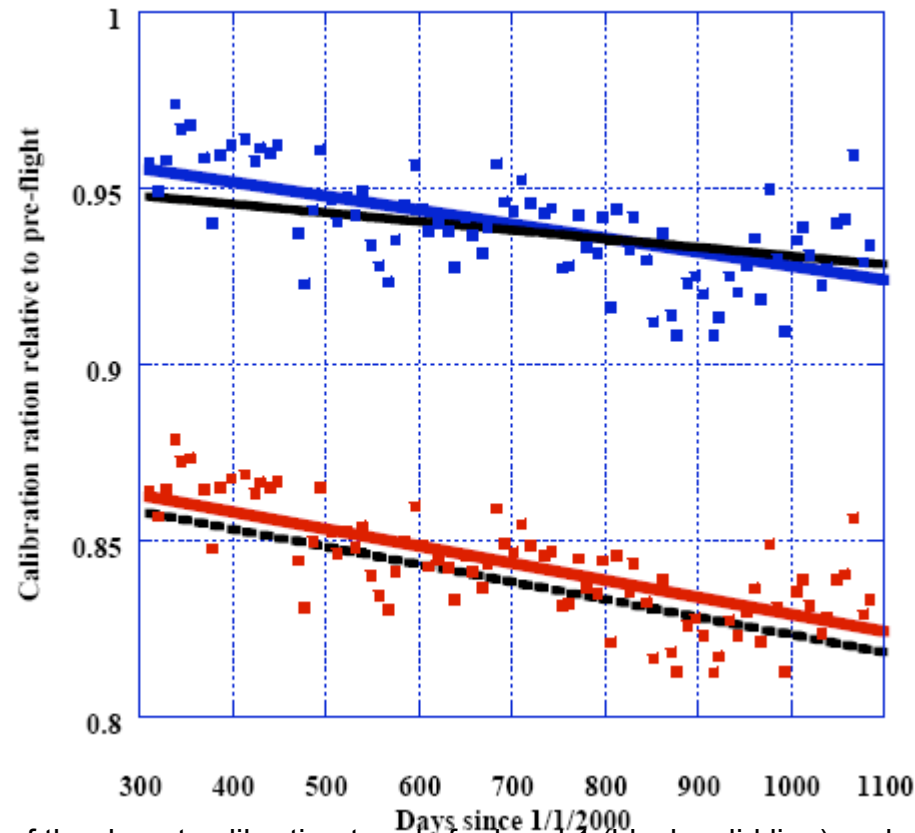
# Error Budget: AVHRR surface reflectance and NDVI summary

	AVHRR Pathfinder-like processing	With LTDR improvements
Calibration	10% absolute, 4% band to band	4% absolute, 2% band to band
Pressure	±10 mbars	±10 mbars
Water vapor	0.7 g.cm <sup>-2</sup> (NCEP or None)	0.3 g.cm <sup>-2</sup> (split window)
Ozone	±30 Dobson (LONDON)	±10 Dobson (EP-TOMS)
Aerosols	No Correction	0.01 error in predicting red refl. from 3.75 μm

/ NDVI	Forest				Savanna				Semi-arid			
	value	Aerosol Optical Depth			value	Aerosol Optical Depth			value	Aerosol Optical Depth		
		clear	avg	hazy		clear	avg	hazy		clear	avg	hazy
ρ Ch1 (VIS)	8	6	0.051	3	6	0.009	7	0.073	3	9	0.039	8
ρ Ch2 (NIR)	0.237	0.020	7	8	6	4	5	0.037	7	9	0.02	9
ρ Ch3 (MIR)	0.045	0.002	6	1	6	2	4	6	3	3	4	4
NDVI	0.682	0.033	0.195	0.266	2	0.042	0.124	0.168	6	0.046	0.068	0.090
ρ Ch1 (VIS)	8	1	0.01	0.01	6	1	1	0.01	3	6	4	4
ρ Ch2 (NIR)	0.237	5	3	6	6	5	1	1	7	1	7	2
ρ Ch3 (MIR)	0.045	4	5	5	6	0	2	6	3	0.003	3	7
NDVI	0.682	0.056	0.058	0.064	2	0.043	0.047	0.054	6	0.03	0.033	0.038



The absolute calibration coefficients derived for NOAA-16 bands 1 and 2, using t were compared to the vicarious coefficients derived using the ocean and clouds (Vermote and Kaufman, 1995). The coefficients were consistent within less than A paper for RSE is in press.



Comparison of the desert calibration trends for band 1 (black solid line) and band 2 (black interrupted line), with the trends obtained using the Ocean and Clouds method (Vermote and Kaufman, 1995) for band 1 (blue line and square) and band 2 (red line and square).

## Second year activities

- Produce an AVHRR surface reflectance and NDVI beta data set using Pathfinder 2 algorithms (vicarious calibration; Rayleigh, ozone and water vapor correction using ancillary data; aerosol retrieval over dark targets).
- Setup a web/ftp interface for data distribution.
- Identify a set of validation sites for use in the evaluation of the products.
- Evaluation of produced data set and start operational QA activity (global browse, known issues, time series monitoring and trends).

## Second year activities (cont.)

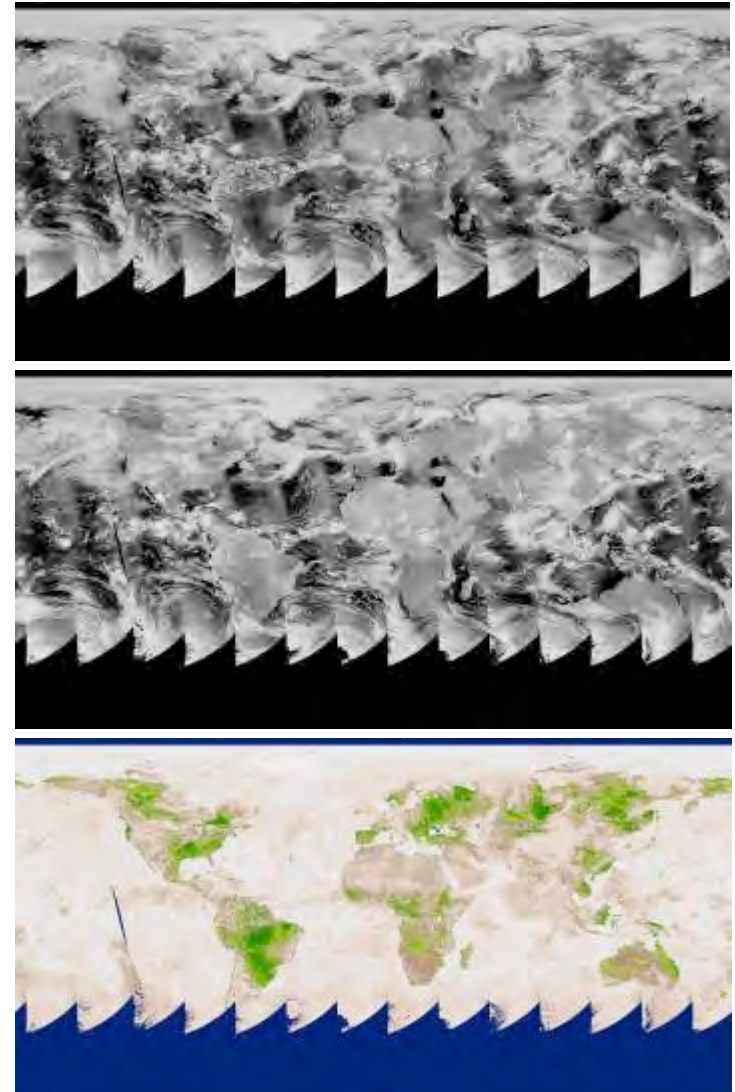
- Develop code to process MODIS coarse resolution surface reflectance (MOD09CRS) into a data set with the same spatial and temporal characteristics as the AVHRR data set for use in evaluation and algorithm improvement.
- Start implementing LAI/FPAR, surface temperature and snow algorithms.
- Implement a community feedback mechanism to address users questions and to capture new requirements and concerns.

## Second year activities (cont.)

- *Expand error budget analysis to include realistic scenarios (rather than worst case) and to account for temporal compositing.*
- *Use coincident MODIS and AVHRR data to improve aerosol retrieval and correction in AVHRR.*

# Production of the Beta Data Set

- Algorithms:
  - Vicarious calibration (Vermote/Kaufman)
  - Cloud screening: CLAVR
  - Partial Atmospheric Correction:
    - Rayleigh (NCEP)
    - Ozone (TOMS)
    - Water Vapor (NCEP)
- Products:
  - Daily NDVI (AVH13C1)
  - Daily surface reflectance (AVH09C1)
  - 16-day composited NDVI (AVH13C3)
  - Monthly NDVI (AVH13CM)
- Format:
  - Linear Lat/Lon projection
  - Spatial resolution: 0.05 Deg
  - HDF-EOS
- Time Period:
  - 1981 – 2000 completed
- Archive and Distribution:
  - Over 1 TB stored online.
  - Distributed by ftp and web

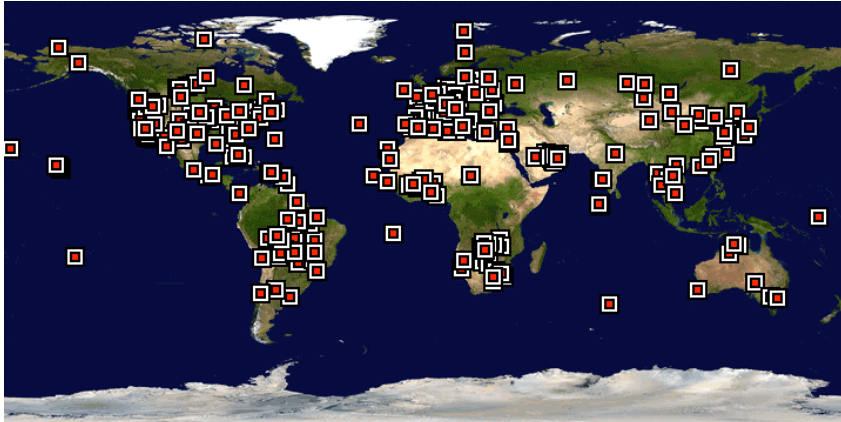


NOAA-11 - 1992193 (7/11/1992) : Ch1,  
Ch2 and NDVI

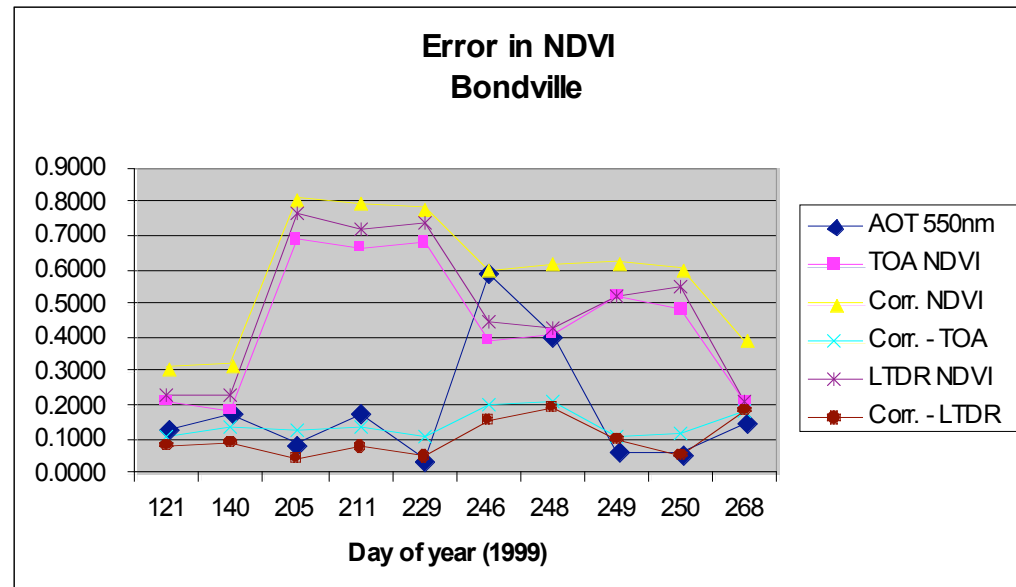
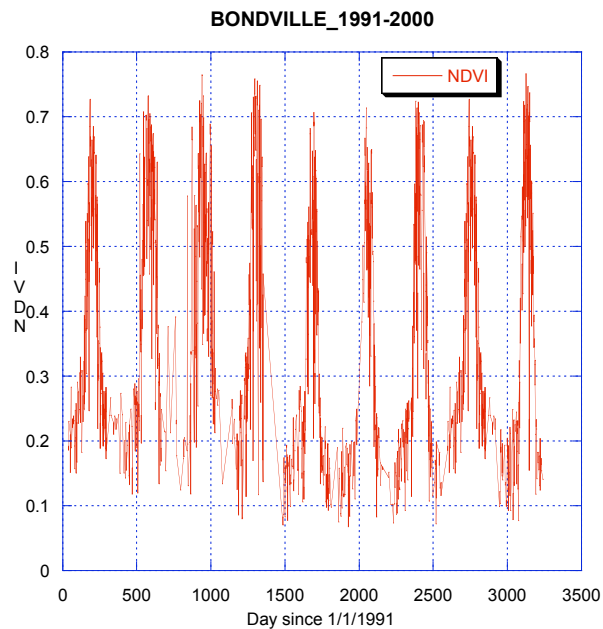
# Data Set Evaluation

- Quality Assessment based on the MODIS Land approach (Devadiga/LDOPE)
  - Inspection of global browse images
  - Time series analysis
- Statistical analysis using non-linear tools (Pinzon/Tucker)
  - Verify the stability of the calibration
  - Comparison to GIMMS and Pathfinder data sets
- Verify theoretical errors using Aeronet data where available and develop product uncertainty estimates (Vermote/Nagol)
- Provided vicarious calibration coefficients to external users (NOAA/CSIRO)
- Beta users applications

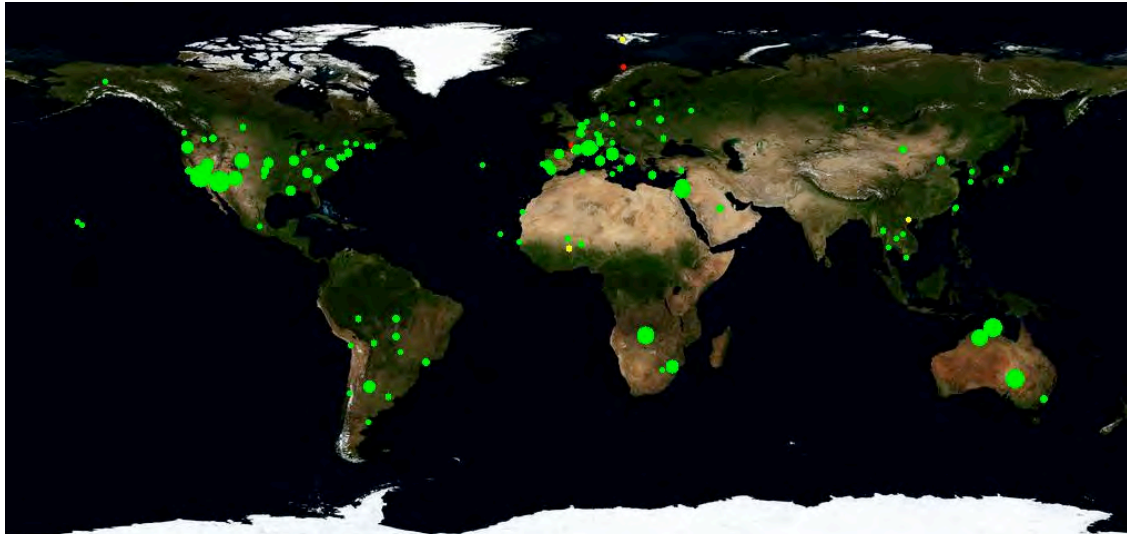
# Data Set Evaluation



- 50x50 km cutouts centered on aeronet sites
- Surface reflectance and NDVI Time series plots posted on the QA webpage.
- Use aeronet AOT and WV measurement when available to assess errors due to lack of atmospheric correction.



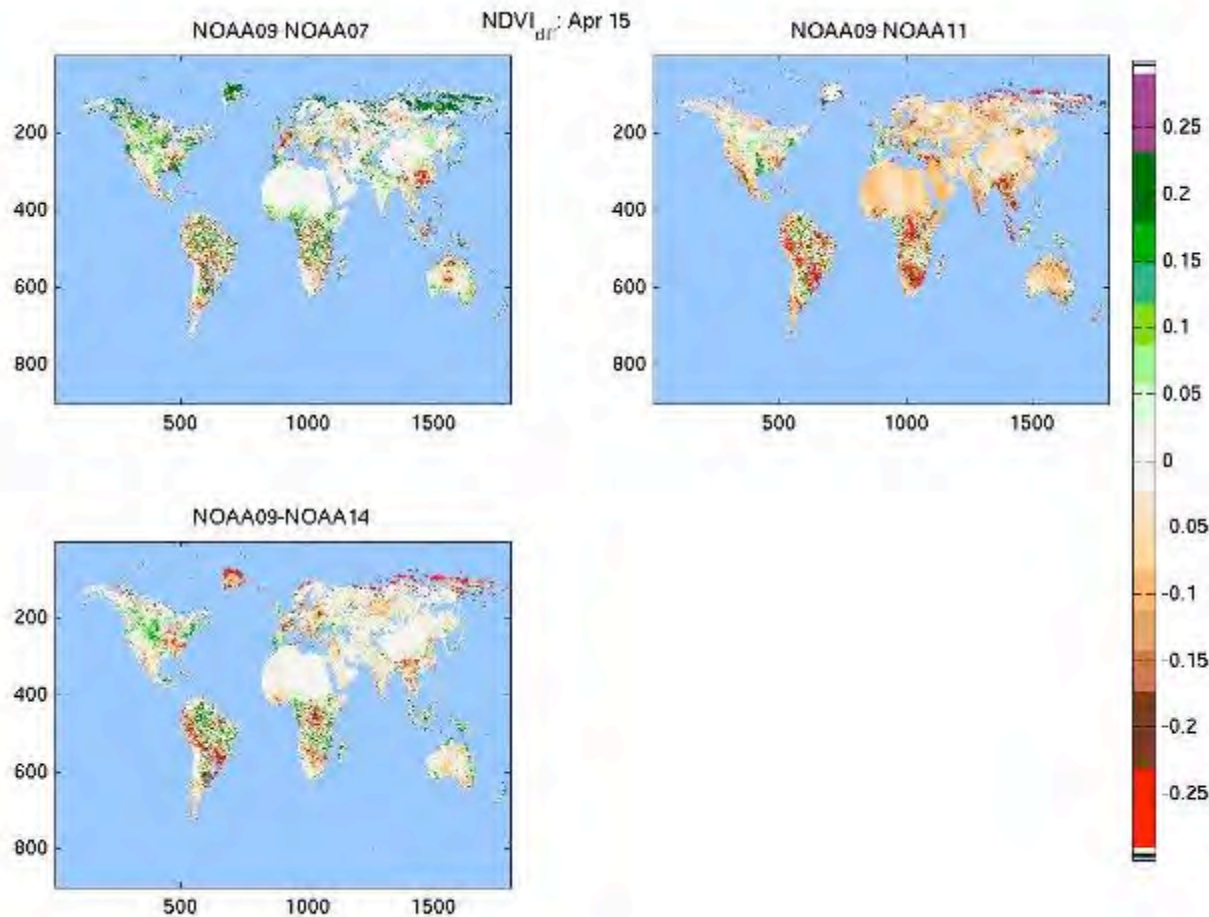
# Evaluation goals (see MODIS poster's, Vermote,Saleous,Kotchenova



Reflectance/ VI	Forest				Savanna				Semi-arid			
	value	Aerosol Optical Depth			value	Aerosol Optical Depth			value	Aerosol Optical Depth		
		clear	avg	hazy		clear	avg	hazy		clear	avg	hazy
$\rho_3$ (470 nm)	0.012	0.0052	0.0051	0.0052	0.04	0.0052	0.0052	0.0053	0.07	0.0051	0.0053	0.0055
$\rho_4$ (550 nm)	0.0375	0.0049	0.0055	0.0064	0.0636	0.0052	0.0058	0.0064	0.1246	0.0051	0.007	0.0085
$\rho_1$ (645 nm)	0.024	0.0052	0.0059	0.0065	0.08	0.0053	0.0062	0.0067	0.14	0.0057	0.0074	0.0085
$\rho_2$ (870 nm)	0.2931	0.004	0.0152	0.0246	0.2226	0.0035	0.0103	0.0164	0.2324	0.0041	0.0095	0.0146
$\rho_5$ (1240 nm)	0.3083	0.0038	0.011	0.0179	0.288	0.0038	0.0097	0.0158	0.2929	0.0045	0.0093	0.0148
$\rho_6$ (1650 nm)	0.1591	0.0029	0.0052	0.0084	0.2483	0.0035	0.0066	0.0104	0.3085	0.0055	0.0081	0.0125
$\rho_7$ (2130 nm)	0.048	0.0041	0.0028	0.0042	0.16	0.004	0.0036	0.0053	0.28	0.0056	0.006	0.0087
NDVI	0.849	0.03	0.034	0.04	0.471	0.022	0.028	0.033	0.248	0.011	0.015	0.019
EVI	0.399	0.005	0.006	0.007	0.203	0.003	0.005	0.005	0.119	0.002	0.004	0.004



# Statistical Analysis



- Abnormally higher values in NOAA-11 over the desert were tracked to the use of incorrect calibration coefficients in production.
- Problem was also detected by the operational QA (time series) and is being corrected.

# Beta Users

In addition to team members, certain users have been identified to use the beta data set in their applications:

- Andy Heidinger / Felix Kogan (NOAA) – Calibration
- Ed King (CSIRO) - Calibration
- Ranga Myneni (BU) - LAI
- Molly Brown (GSFC) - NDVI
- Marc Leroy (CESBIO/MediaFrance) : subset over East Africa : Evaluation of calibration and surface reflectance.
- Ana Pinheiro (GSFC) – Brightness/Surface temperature
- Menglin Jin (UMD) – Brightness/Surface temperature
  
- Users expressed interest in using the data set in EOS proposals
  - Anderson (BU)
  - Bounoua (GSFC)

# LTDR Web Page

The image shows two overlapping browser windows from Mozilla Firefox. The left window displays the main LTDR website, and the right window shows a sub-page for AVHRR Calibration.

**LTDR home - Mozilla Firefox**  
http://ltdr.nascom.nasa.gov/ltdr/ltdr.html

## LTDR

Land Long Term Data Record

LTDR is a NASA-funded REASoN project to produce a global coastal AVHRR, MODIS and VIIRS for Land studies. The project will create reflectance and NDVI at a resolution of 0.05 degrees. Higher order LAI/FPAR, albedo will be created at a coarser temporal resolution. AVHRR data onboard NOAA satellites from 1981 - present.

- [Project Overview and Science Background](#)
- [Documents and Presentations](#)
- [AVHRR Vicarious Calibration](#)
- [Data Products](#)
- [Participants](#)
- [Feedback](#)
- [Updates/ Changes History](#)

**Index of ftp://ltdr.nascom.nasa.gov/**

Up to higher level directory

- AVH09C1.A1983001.N07.001.2006027
- AVH09C1.A1983001.N07.001.2006027
- AVH09C1.A1983002.N07.001.2006027
- AVH09C1.A1983002.N07.001.2006027
- AVH09C1.A1983003.N07.001.2006027
- AVH09C1.A1983003.N07.001.2006027
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- AVH09C1.A1983006.N07.001.2006027
- AVH09C1.A1983007.N07.001.2006027
- AVH09C1.A1983007.N07.001.2006027
- AVH09C1.A1983008.N07.001.2006027

**LTDR AVHRR Calibration - Mozilla Firefox**  
http://ltdr.nascom.nasa.gov/ltdr/avhrr\_calib.html

## LTDR

### AVHRR Calibration

Land Long Term Data Record

Consistent and accurate calibration is a pre-requisite to creating a long-term data record. The AVHRR instrument suffers from the lack of onboard calibration for its visible to short wave infrared channels. Various vicarious calibration approaches were employed by users to account for the sensor degradation. For the LTDR REASoN project, we adopted the approach developed by Vermote and Kaufman (1995) that relies on clear ocean and accurate Rayleigh scattering computations to derive the sensor degradation in the red bands. This approach uses high clouds to predict the variation in the NIR to Red ratio and transfer the calibration to the NIR channel. This approach does not require any in situ or aircraft measurements and is applied consistently across the AVHRR instruments onboard various NOAA satellites. Click on the satellite link to get the calibration coefficients for the corresponding AVHRR (NOAA-7, NOAA-9, NOAA-11, NOAA-14, NOAA-16).

The figure consists of two scatter plots showing the degradation of AVHRR channels over time (1980-2005). The top plot shows 'Degradation in channel 1 (from Ocean observations)' and the bottom plot shows 'Channel 1/Channel 2 ratio (from Cloud observations)'. Both plots show data points for NOAA-7, NOAA-9, NOAA-11, NOAA-14, and NOAA-16, with a trend line indicating a decrease in degradation over time.

http://ltdr.nascom.nasa.gov/ltdr/avhrr\_calib.html

<http://ltdr.nascom.nasa.gov/ltdr/ltdr.html>

# Operational Quality Assurance

The screenshot shows the NASA Goddard Space Flight Center website for the Land Long Time Data Record (LTDR) Quality Assessment. The page features a header with the NASA logo and 'GODDARD SPACE FLIGHT CENTER', a link to the 'NASA Homepage', and a title 'Land Long Time Data Record Quality Assessment' over a satellite image background. A left sidebar contains links for 'LTDR Products', 'LTDR File Specification', 'Calibration', 'Global Overview', 'Data Sources', 'Known Product Issues', 'QA Tools', 'Science Team Meeting', 'QA Personnel', 'FAQ', and 'Feedback'. The main content area has a 'Welcome to the Land Long Time Data Record Quality Assessment Web Page' section, followed by a paragraph explaining the objective of LTDR QA: to evaluate and document the scientific quality of global LTDRs (Long Term Data Records) made from remotely sensed data acquired using AVHRR, MODIS, and VIIRS. It notes that LTDRs are currently produced as single global data records for each science parameter at a coarse resolution of 0.05 deg, and that any discrepancies or QA-related issues are posted as known issues on the Known Issues web page. The footer includes the 'FIRST.GOV' logo, a link to the 'Privacy Policy and Important Notices', the NASA logo, contact information for the Web Master (Min Zheng) and NASA Official (Ed Masuoka), and links to the 'LTDR QA Home Page' and 'LTDR Home Page', with a 'Last Updated: May 3, 2006' date.

NASA GODDARD SPACE FLIGHT CENTER [+ NASA Homepage](#)

## Land Long Time Data Record Quality Assessment

[LTDR Products](#)  
[LTDR File Specification](#)  
[Calibration](#)

[Global Overview](#)  
[Data Sources](#)  
[Known Product Issues](#)  
[QA Tools](#)

[Science Team Meeting](#)  
[QA Personnel](#)  
[FAQ](#)  
[Feedback](#)

### Welcome to the Land Long Time Data Record Quality Assessment Web Page

The objective of LTDR QA is to evaluate and document the scientific quality of the global LTDRs (Long Term Data Records) made from remotely sensed data acquired using AVHRR (Advanced Very High Resolution Radiometer), MODIS (Moderate Resolution Imaging Spectroradiometer) and VIIRS (Visible/Infrared Imager Radiometer). LTDRs are currently being produced as single global data record for each science parameter at a coarse resolution of 0.05 deg. Any discrepancy in the data records or QA related issues identified the QA process are posted as known issues on the Known Issues web page at this site. These issues are updated as the new version of data records are produced using improved algorithm.

**FIRST.GOV**  
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NASA

Web Master: [Min Zheng](#)  
NASA Official: [Ed Masuoka](#) Code 614.5  
[+ LTDR QA Home Page](#)  
[+ LTDR Home Page](#) Last Updated: May 3, 2006



# Operational QA : Global Browse


**GODDARD SPACE FLIGHT CENTER**

[NASA Home](#)

## Land Long Time Data Record



LTDRs are produced as CMG (Climate Modeling Grid) products at 5km resolution. Global browse images created from these data records are posted at this web site to enable synoptic quality assessment of the data records. This web interface supports interactive selection of browse products and zooming and panning at 5km resolution.

**Browse Availability:**  
 NOAA-07: 1981-176 — 1984-365  
 NOAA-09: 1985-001 — 1988-312  
 NOAA-11: 1988-313 — 1994-365  
 NOAA-14: 1995-001 — 2000-365

Please direct your questions and comments to Nazari Saleous at [nazari.saleous@gsfc.nasa.gov](mailto:nazari.saleous@gsfc.nasa.gov).

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**Please Select:**

**Satellite:**

☒ NOAA-07

☐ NOAA-09

☐ NOAA-11

☐ NOAA-14

☐ NOAA-16

**Collection:**

☒ Collection I

**Products:**

**Daily:**

Surface Reflectance: ☒ AVH09C1 (Band 2)

Vegetation Index: ☒ AVH13C1 (NDVI)

**8 days:**

Surface Reflectance: ☒ AVH09C2

Vegetation Index: ☒ AVH13C2

**16 days:**

Vegetation Index: ☒ AVH13C3

**Monthly:**

**Dates:**

Last - Input the date:

1984-001 Start date



















1984-005 End date

(Format: YYYYDDD)



[Click Here for the Calendar](#)

## Collection 001

Julian day	Daily Surface Reflectance (AVH09C1)	Daily Vegetation Index (AVH13C1)	8-day Surface Reflectance (AVH09C2)	8-day Vegetation Index (AVH13C2)	16-day Vegetation Index (AVH13C3)	Monthly Vegetation Index (AVH13C3)
1982 001						Not Available
001						
1982 001						
01 01						
1982 010						
01 10						
1982 020						
01 20						
1982 028						
01 28						
1982 027						
01 27						
1982 036						
01 26						
1982 028			Not Available	Not Available		
01 08						
1982 021						
01 21						

# Operational QA : Time Series

NASA GODDARD SPACE FLIGHT CENTER

Land Long Time Data Record

Time Series

A time series of summary statistics derived from all the LTDR products at a number of fixed globally distributed locations is maintained and monitored by the LTDR QA personnel in order to enable synoptic quality assessment via the internet. Time series statistics are extracted at all aeronet sites and also nine MODIS Land Golden Tiles. Product time series are important because they capture algorithm sensitivity to surface (e.g. vegetation phenology), atmosphere (e.g. aerosol loading) and remote sensing (e.g. sun-surface-sensor geometry) conditions that change temporally, and because they allow changes in the instrument characteristics and calibration to be examined. Please select the year and an aeronet site (listed in alphabetical order) or tile and biome combination).

First: Second: C Aeronet Golden Tile

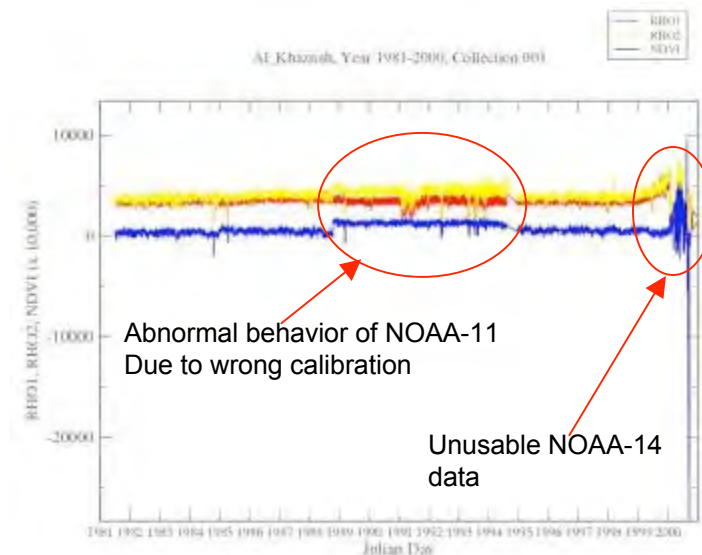
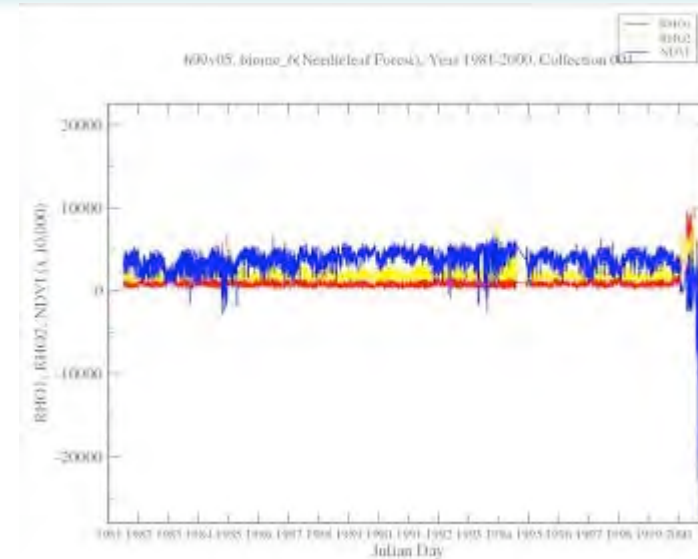
Year: 1992 1993 1994 1995 1996 1997 1998 1999 2000 all

Aeronet area: A B C D E F G H I J

Tiles: h09v05 h11v03 h11v08 h11v11 h17v07 h20v11 h24v04 h26v01 h32v11

Biomes: biome\_0 (Water) biome\_1 (Grasses/Cereals) biome\_2 (Shrubs) biome\_3 (Broadleaf Crops) biome\_4 (Savanna) biome\_5 (Broadleaf Forest) **biome\_6 (Needleleaf Forest)** biome\_7 (Unvegetated) biome\_8 (Urban)

Submit the Request



# Operational QA : Known Issues

**Land Long Time Data Record**

**Quality Assessment**

**LTD QA - Known Product Issues**

QA related issues found as a result of QA performed by the LTD QA group and Science Team are posted below. The issues are updated after each reprocessing of the data records with improved algorithm.

**AVHRR Land Products**

- [Surface Reflectance \(AVH09\)](#) *Publicly available*
- [Vegetation Index \(AVH13\)](#) *Publicly available*

Updated May 3, 2006

Color Key: Case pending Case closed Case reopened QA note					
Case number	Opening Date	Last Update (Sort)	Status	Description	
CC AVH09C1 06130b	05/18/06	05/18/06	Pending	Discontinuities in image reconstruction	
CC AVH09C1 06130a	05/18/06	05/18/06	Pending	Cloud mask for some pixels inconsistent with surroundings	
CC AVH09C1 06131a	04/21/06	04/21/06	Note	Some pixels labeled as "dark dense vegetation"	
CC AVH09C1 06111f	04/21/06	05/17/06	Pending	Striping in cloud mask, L3, RH03 fields	
CC AVH09C1 06111e	04/21/06	05/17/06	Pending	River and delta flagged as cloud	
CC AVH09C1 06111d	04/21/06	04/21/06	Note	No flag indicating dust or heavy aerosol in AVHRR data	
CC AVH09C1 06111c	04/21/06	04/21/06	Pending	Cloud mask labels some clear pixels as cloudy	
CC AVH09C1 06111b	04/21/06	05/18/06	Pending	Areas of data inconsistent with surroundings	
CC AVH09C1 06111a	04/21/06	05/11/06	Pending	Some RH01 and RH02 reflectance values exceed 1.0	

## SEEDS Activities

- Participated in the Reuse Working Group
- Participated in the Metrics Planning and Reporting Working Group (MPARWG)



## Planned activities for the third year

- Complete evaluation of the beta data.
- Outreach activities
  - Vegetation workshop – Aug '06 Montana
  - Hold a special session at Fall'06 AGU to present results and get feedback.
  - MODIS Land Collection 5 workshop (Jan'07).
- Implement BRDF correction of AVHRR data to remove biases introduced by the orbital drift and changes in the solar and viewing geometries throughout the record.
- Complete implementation of LAI/FPAR and albedo algorithms.
- Compare AVHRR and MODIS data sets to quantify differences and to start addressing continuity issues (starting with higher order products).

# Summary

Done:

- Created and started evaluating an AVHRR surface reflectance and NDVI Beta data set.
- Distributed the data set to selected beta users who will evaluate it in the context of their application.
- Posted the Beta data set and the associated QA webpage on the web.
- AVHRR vicarious calibration paper in review/revision.

To be done:

- Complete evaluation and comparison with Pathfinder and GIMMS data sets.
- Hold AGU session on Land Coarse Resolution Long Term Data Record.
- Implement LAI/FPAR and BRDF algorithms.

# ESDR pathfinding

- This project provides a pathfinding activity for NASA's Land ESDRs with respect to inter-instrument calibration, product generation, QA and distribution.
- AVHRR data gaps
  - Two major data gaps exist in the AVHRR PM record.
    - The first one (end of 1994) can be filled using NOAA-09.
    - An option to fill the second one (1999->2000) requires the use of SPOT Vegetation data.
- The current project does not include collection and processing of AVHRR AM data. As with Terra and Aqua MODIS, AM and PM AVHRR data are useful for Thermal products and to improve BRDF retrievals.
- AVHRR on METOP will provide a longer overlap with MODIS.
- Obtaining and processing SPOT and METOP data require collaboration with foreign data producers. This provides an opportunity to test International cooperation in the creation of ESDRs.